The use of remotely sensed data to analyze the spatial and temporal inundation dynamics of coastal lakes in the Western Cape, South Arica.

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Topics

- Introduction
- Research aim and objectives
- Study Area
- Methods
- Results
- Findings and conclusion

Introduction and background information

- **South Africa is a country facing increasing water challenges** (Makapela et al., 2015), influenced by factors such as climate change, rapid population growth and economic development (Grenfell et al., 2016).

- **Wetlands are some of the most vulnerable aquatic ecosystems** that faces many pressures affecting their ecological functioning (Skowno et al., 2018).

- In addition, there is a **decreasing trend in the spatial extent of wetland ecosystems** in South Africa that needs to be frequently examined considering continued drought periods (Van Deventer et al., 2020).

- To understand how surface water changes over time, **frequent inundation monitoring** is however critical (Liu et al., 2012).

- **Consequently the frequency of inundation patterns may influence the spatial coverage and temporal duration of surface water** (Zhao et al., 2014). The seasonality of wetland water coverage/ levels may also affect the ecological characteristics and biochemical processes within wetlands (Pal and Saha, 2017; Ward, 2019).

Rationale

- **Time series analysis** of remotely sensed data is one of the important methods **to monitor surface water changes** in waterbodies.

- The relevance of **remote monitoring** of wetlands **using freely available satellite images** and **water extraction** techniques has widely **demonstrated in providing valuable data and information** particularly when validated by high resolution data and in –situ data (Van Deventer et al., 2019; Gxokwe et al., 2020).

- Remotely sensed products, such as the **Sentinel 2 satellite imagery** that has 10-20 m spatial resolutions can map the changes in wetland extent, which has the **potential to serve South Africa's future reporting** data of the **SDG 6.6 indicator on aquatic ecosystems** (Van Deventer et al., 2019).

- Consequently, **few studies classified the spatial and temporal variation of inundation periods for wetlands such as coastal lakes.**

- Considering the potential of remotely sensed data, **the Sentinel 2A MSI satellite imagery was used to assess the variation of the surface water frequency, hydroperiod and spatial extent for coastal lakes located in the Western Cape.**

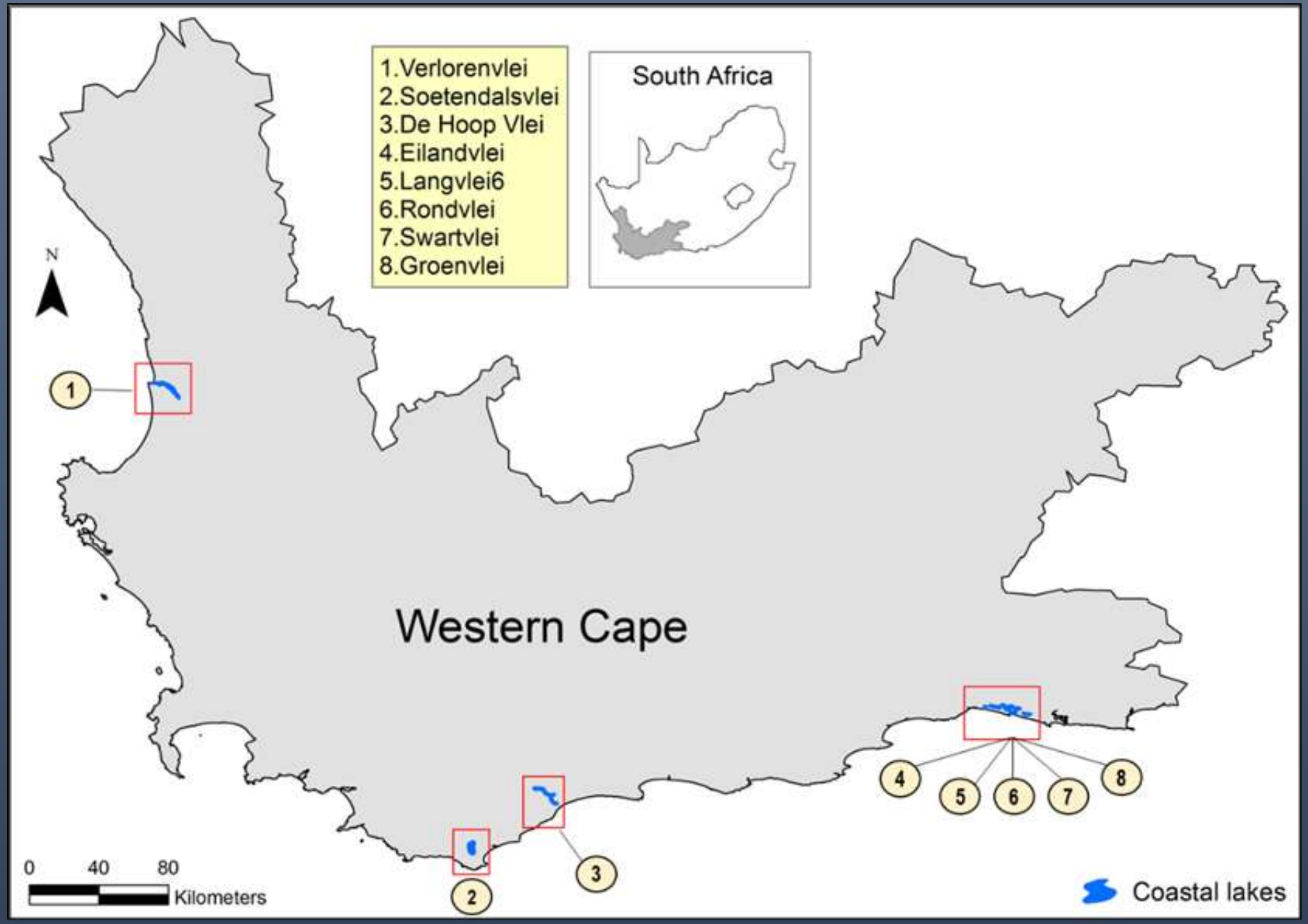
Aim

This research aims to improve the knowledge and understanding of coastal wetland inundation, by using remotely sensed data to assess the spatial and temporal dynamics of coastal lake surface water.

Objectives

1. To assess the suitability of remote sensing classification techniques to monitor surface water of coastal lakes.
2. ***To describe the spatial and temporal inundation of coastal lakes using remote sensing datasets.***
3. To assess the relationship between remotely sensed derived classification and in-situ data.

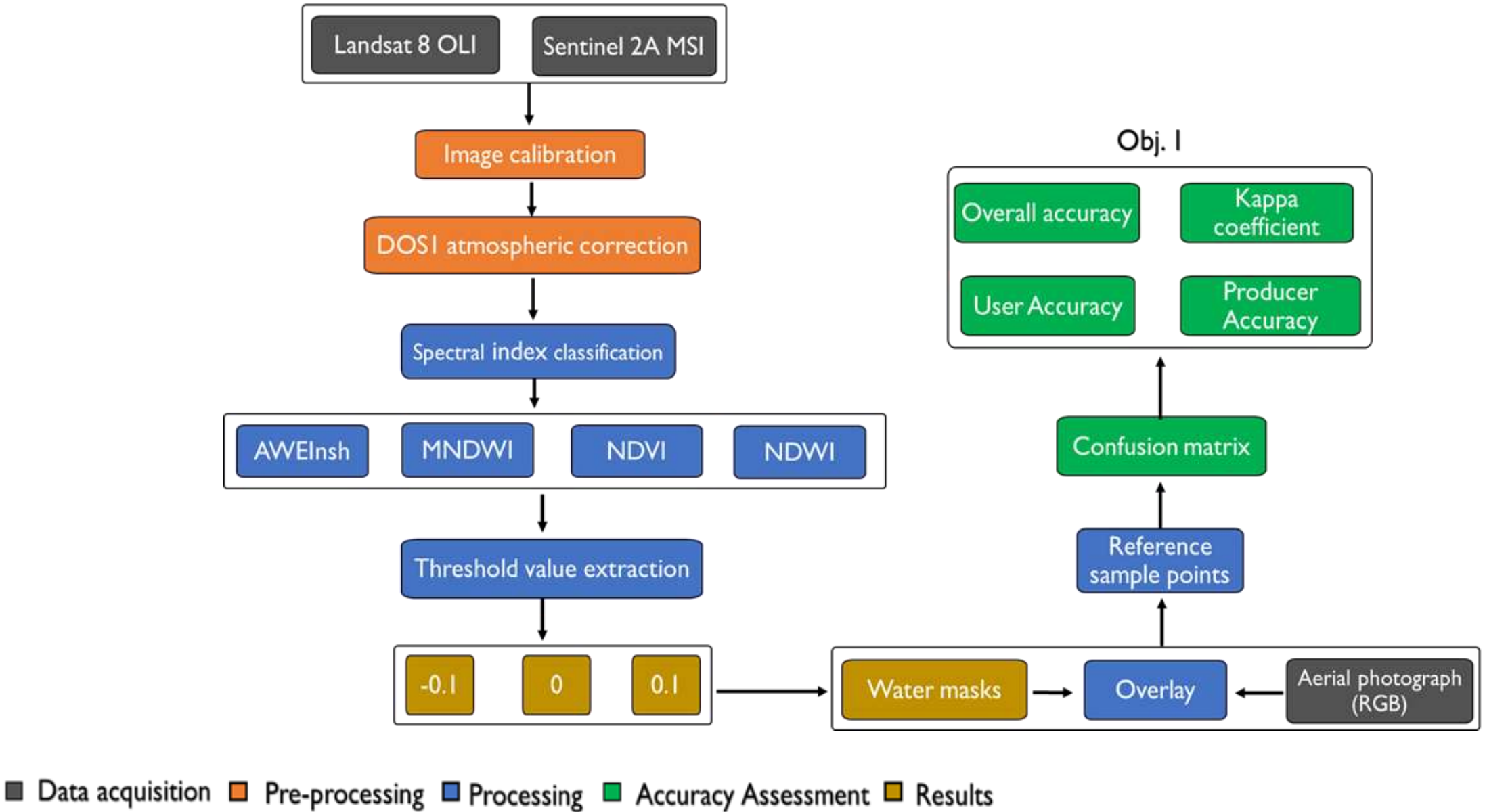
Study area


1.Verlorenvlei
2.Soetendalsvlei
3.De Hoop Vlei
4.Eilandvlei
5.Langvlei6
6.Rondvlei
7.Swartvlei
8.Groenvlei
South Africa
N
Western Cape
1
2
3
4
5
6
7
8
0
40
80
Kilometers
Coastal lakes

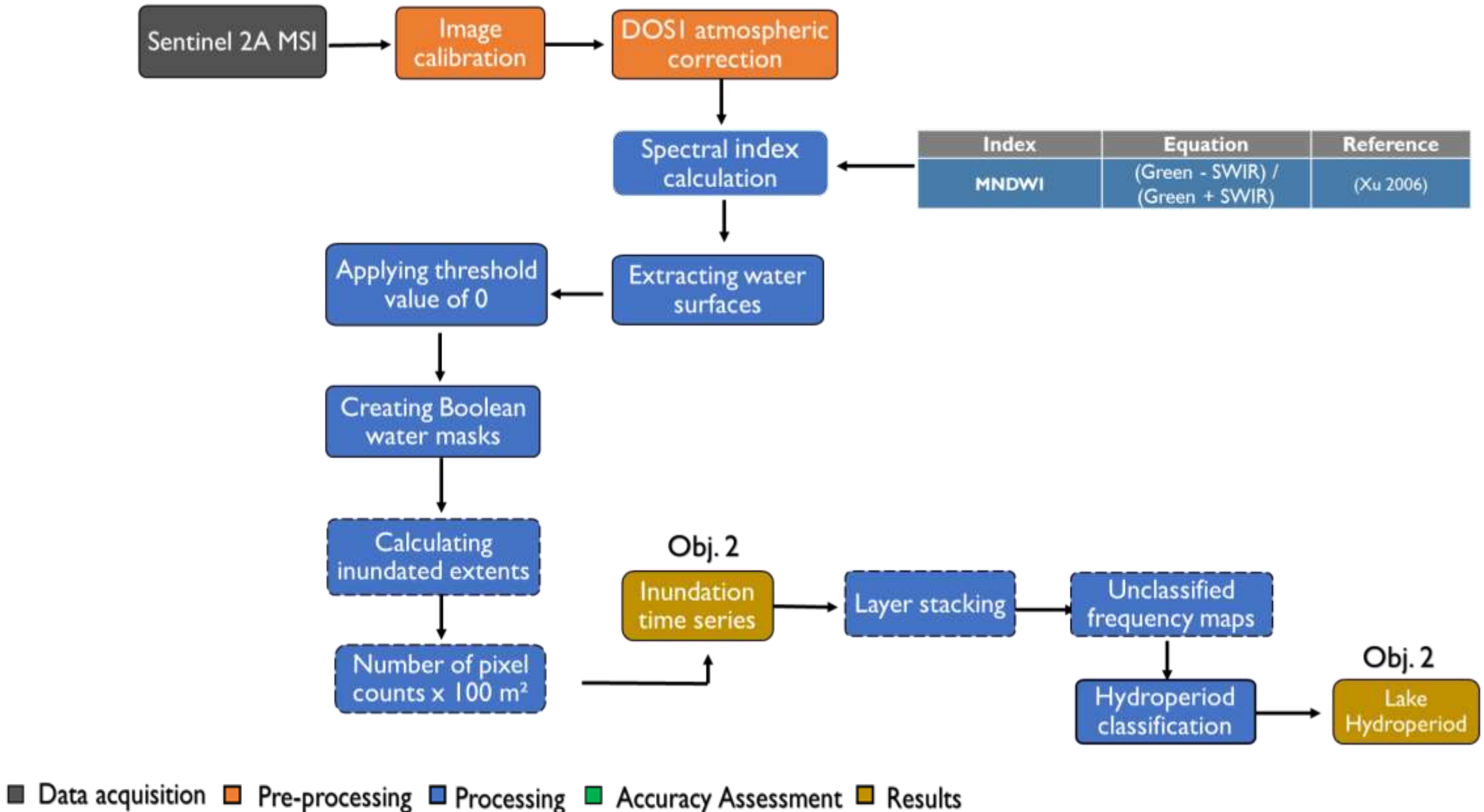
Coastal Lake	Site importance	Ramsar site no.
De Hoop Vlei	Important hunting area for White pelican (*Pelecanus onocrotalus*) that represents 9% of the regional south-western Cape population of 653. Extensive beds of submerged macrophyte (*Potamogeton pectinatus)* in the lake contributes to species richness and habitat. The lake is host to at least 75 bird species, including 12 of the 18 South African waterfowl species. Only one indigenous fish species (*Sandelia capensis*) was recorded at the lake.	34
Groenvlei	Both the Blackbanded Damsel (*A. breviceps*) and Roundherring (*G. aestuaria*) were recently genetically differentiated from other estuarine population species to such an extent that the Groenvlei stocks deserve special conservation attention.	–
Soetendalsvlei	Part of the highly important Heuningnes Estuary in the southern Cape, with several waterfowl species recorded at the lake and not within other parts of the estuary.	342 (Heuningnes Estaury)
Swartvlei	Swartvlei systems support one of South Africa's most significant waterbird assemblages. Weed drift also helps redistribute nutrients within Swartvlei Estuary and supporting large numbers of detritus feeders such as amphipods and mullet.	–
Verlorenvlei	Important feeding area for the rare White pelican. During dry periods large numbers of flamingos (*Phoenicopterus ruber roseus and P.minor*) may occur. The lake supports diverse communities of flora and is an ecotone between the karroid and fynbos vegetation types.	525
Wilderness lakes (Eilandvlei,Langvlei, Rondevlei)	Provide habitat support for important seasonal migrant water birds. It also hosts 285 native plant species such as the Red Satyre (*Satyrium princeps*), 32 fish species and a diverse marine invertebrate fauna. The lakes provide a major form of flood control and their interconnecting channels are dredged to prevent blockage through siltation and growth of aquatic macrophytes.	524

Materials and Methods

Objective 1: Suitability of remotely sensed data and spectral water indices to monitor the coastal lake inundation.

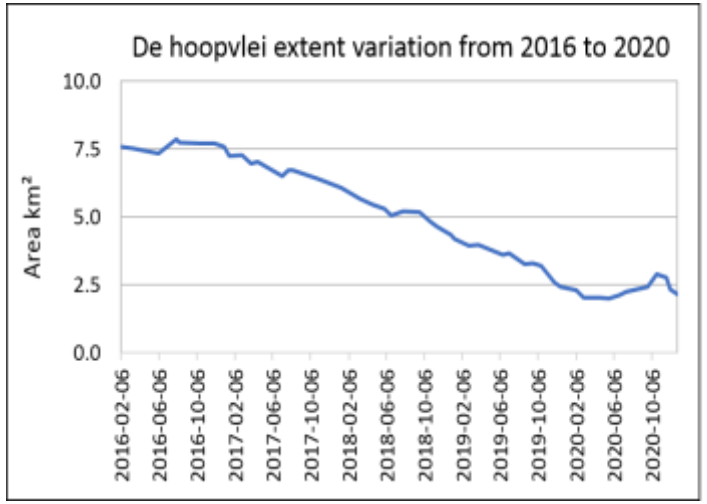


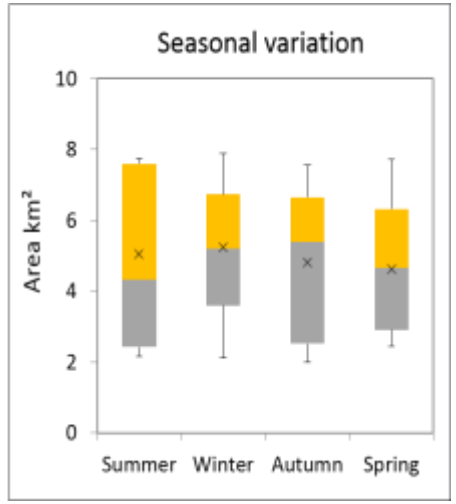
Objective 2: Assessing the spatial and temporal inundation of coastal lakes.



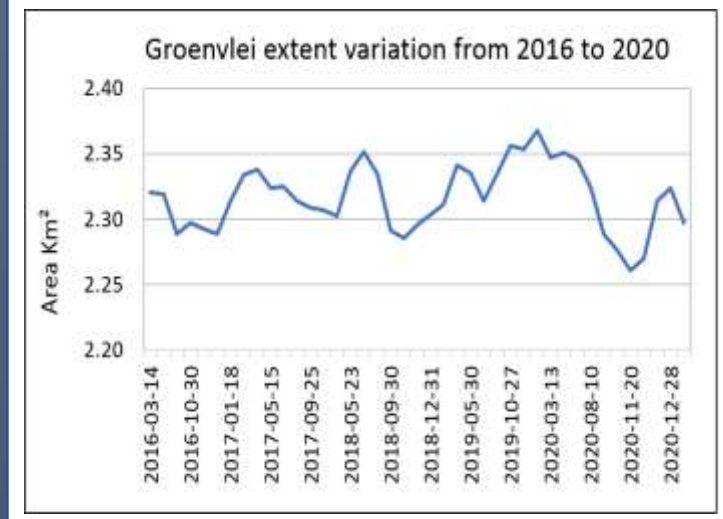
Coastal lake time series extents from 2016-2020

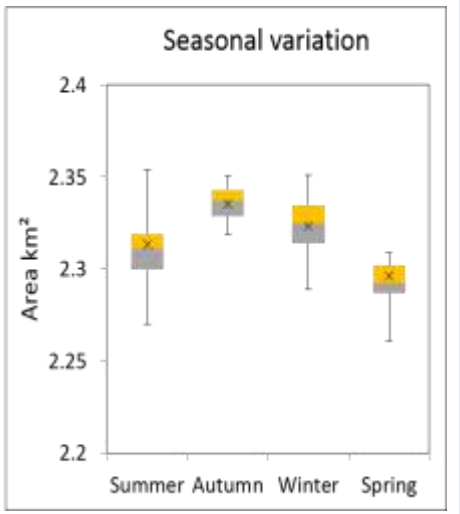
De Hoop Vlei



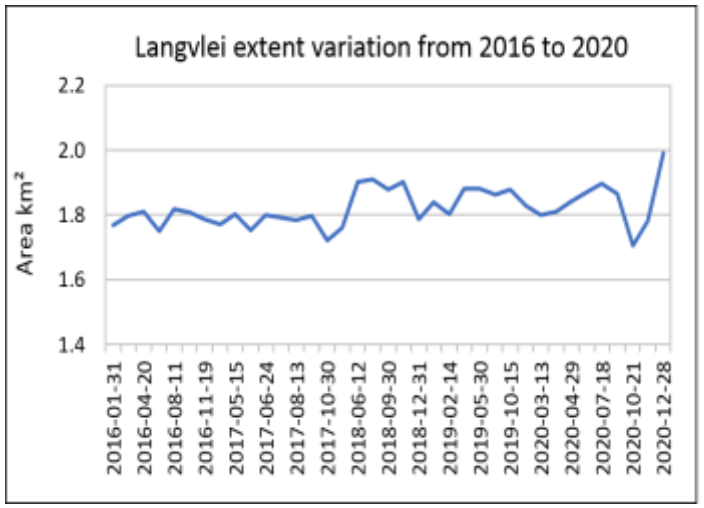


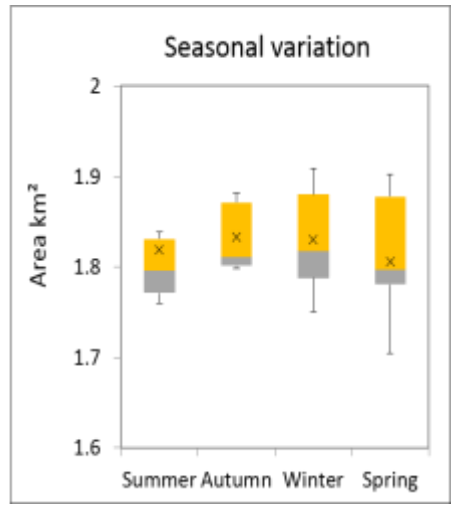
Groenvlei



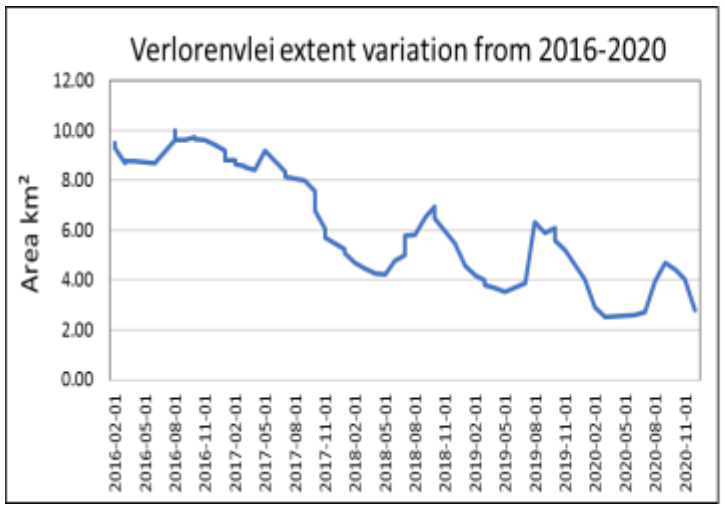


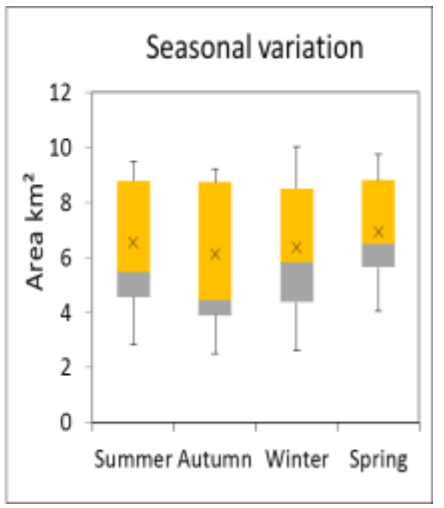
Langvlei





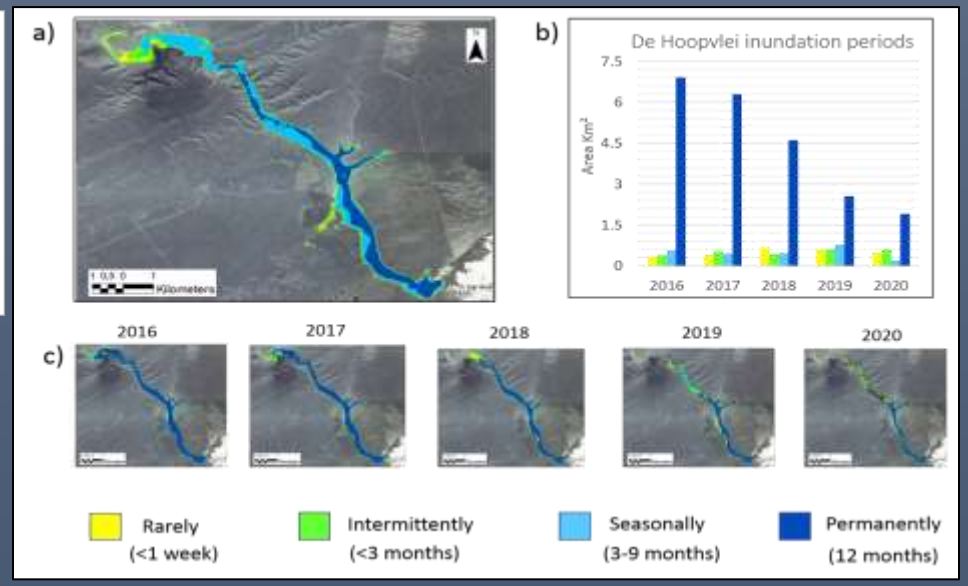
Verlorenvlei



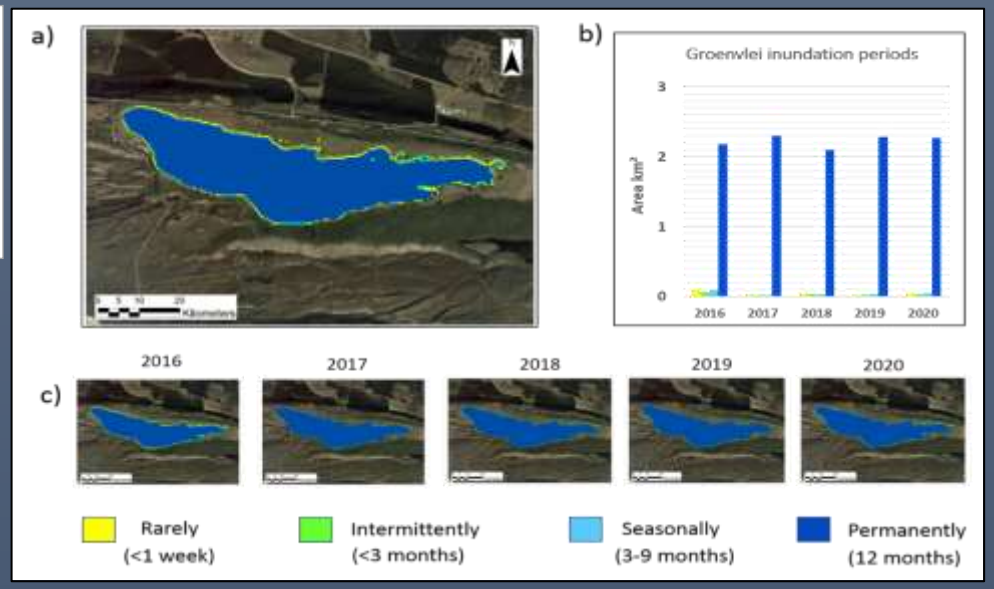


Coastal lake hydroperiod variation from 2016-2020

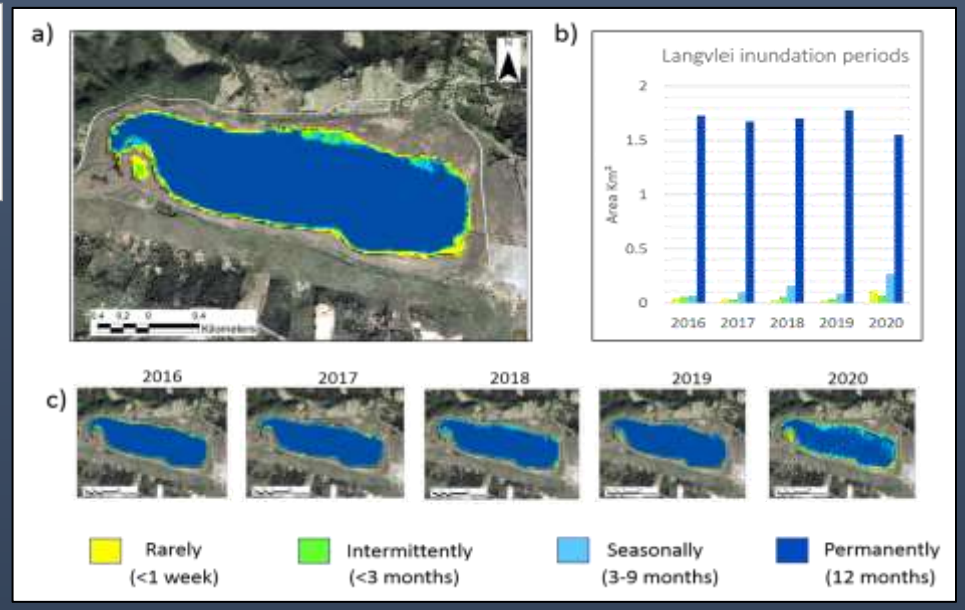
De Hoop Vlei



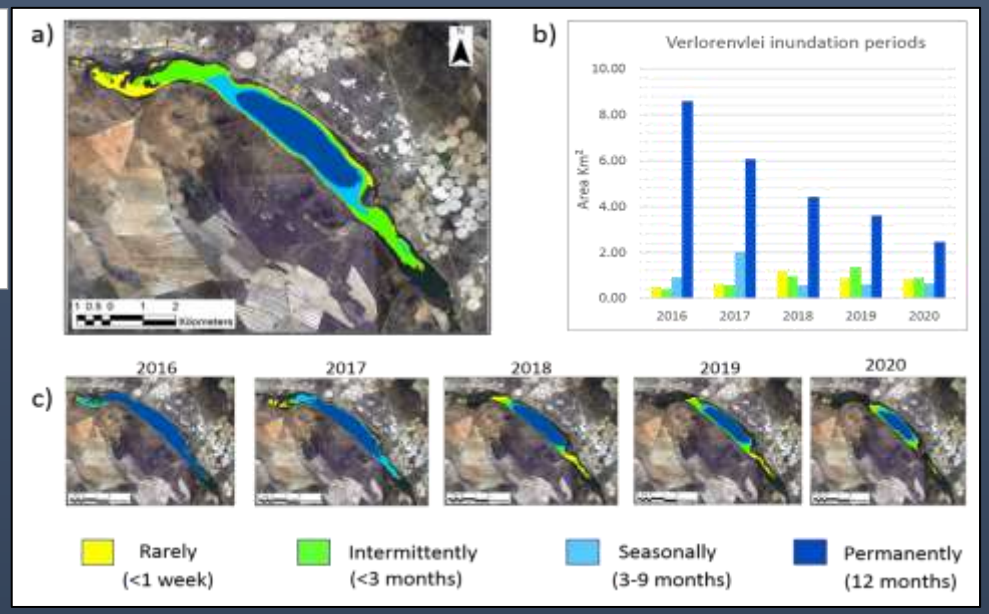
Groenvlei



Langvlei

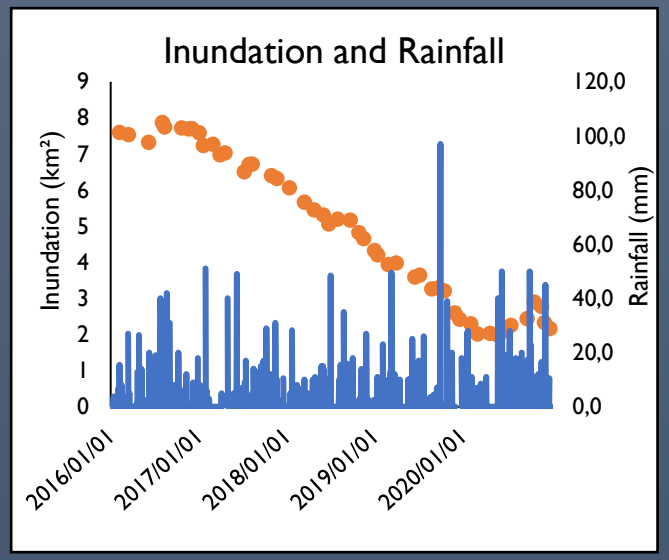


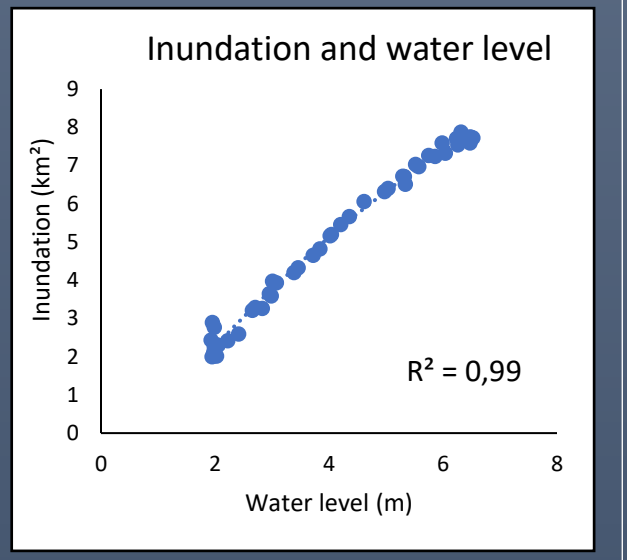
Verlorenvlei



Comparison of in-situ with lake remotely sensed data

De Hoop Vlei





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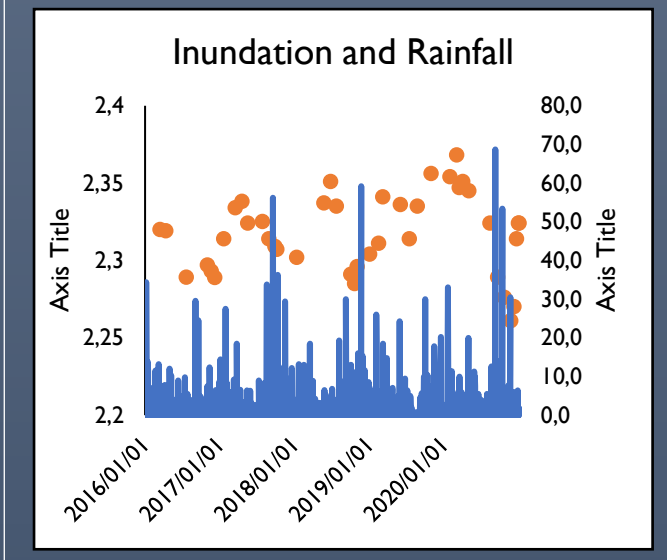
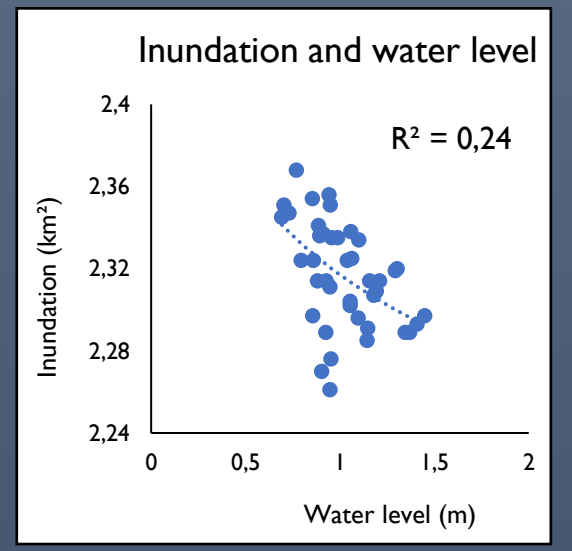
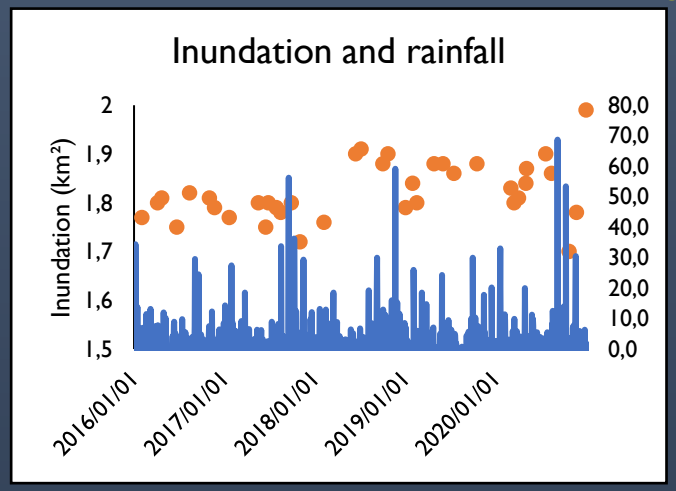
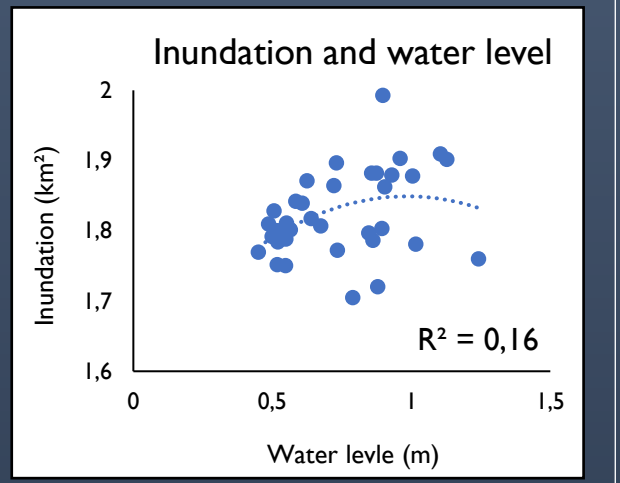


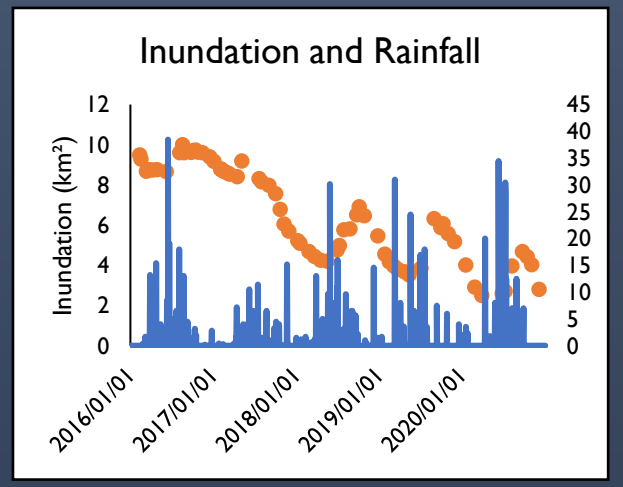


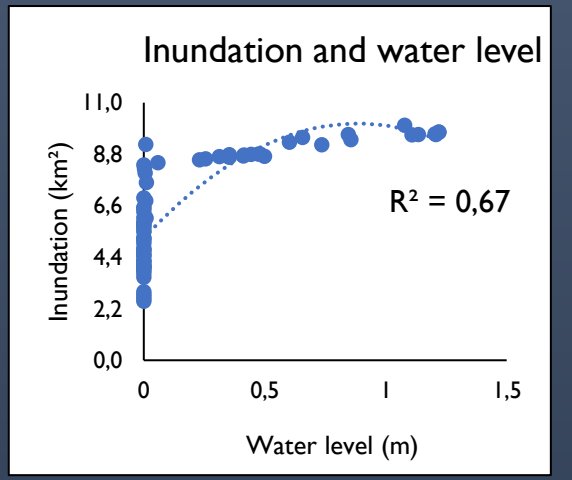
Langvlei





Verlorenvlei





Findings and conclusion

- The time series results illustrated that some lakes had observable changes in their spatial extents from 2016 to 2020, with varying increases and decreases. Most of the coastal lakes had permanently inundated surface areas covering their extents, suggesting that standing water covering surfaces of the lakes, were always present throughout the five-year time series.

- However, there were significant hydroperiods variations, especially those showing a decrease in surface water coverage, which may significantly affect biodiversity and ecological functioning within the aquatic ecosystems.

- Based on hydroperiod and time series results, the drought may have a significant effect on the water quantity of the De Hoop vlei and Verlorenvlei lakes, with decreases in inundated areas observed from 2016 until 2020.

Findings and conclusion

- Furthermore, the lakes in the Southern Cape had no observable inundation trends, suggesting less severe responses to the drought.

- There were significant comparisons between MNDWI derived inundation and water level for select lakes. There was low rainfall correlation with remotely sensed derived inundation. This suggests that rainfall has a small impact on the hydrology of the lakes and that other sources may influence change in water level.

- The frequent changes in wetland spatial extents suggest that stronger efforts should be put towards surface water monitoring and conservation, meaning, it is critically important for effective water resource management (Bhaga et al., 2020) by considering how their change can impact the functioning of freshwater ecosystems, and to maintain the provision of crucial ecosystem services.

Research significance: Management and conservation of aquatic ecosystems from Earth observation technology

Source	Goal	Description	Targets/Objectives	Recommendation	Research Impact
Convention of Biological Diversity	Post-2020 Global Biodiversity Framework: Goal A	The integrity of all ecosystems is enhanced, with an increase of at least 15 per cent in the area'	By 2030, assess the net gain in the area, connectivity, and integrity of natural systems of at least 5 per cent.	Potential use of earth observation technologies to take on the challenge of changes in wetlands.	Chapter 5 illustrated that frequency and duration of inundation cover, changes frequently in extent through the use of remotely sensed data with high correlation in classification of surface water change in chapter 4. Contributing to special issue of Remote Sensing and Global Restoration of Wetlands.
The United Nations	Sustainable Development Goal 6	'Ensure availability and sustainable management of water and sanitation for all'	In terms of aquatic ecosystems, SDG target 6.6 states: ‘By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes’	Detailed classification of the hydroperiod as per the classification system for wetlands and other aquatic ecosystems (Van Deventer, 2021).	The hydroperiod in chapter 5 illustrated the permanently inundated areas over the time, the consequences for management and ecological functioning of the freshwater system.
Local Framework					
National Biodiversity Assessment	Inform development and implementation of National Biodiversity Tools: NBSAP and NBF	Provides the science that informs the strategic objectives and priority actions of the NBSAP and NBF	In terms of Strategic Objective 3: Biodiversity considerations are mainstreamed into policies, strategies and practices of a range of sectors.	Outcome 3.1: Effective science-based tools inform planning and decision making.	Using remote sensing as a tool to monitor freshwater ecosystems, in which both chapter 4 and 5 applied techniques for wetland surface water detections and mapping as well as potential proxy for water level based in chapter 6.
	Research, monitoring, and data management	Knowledge foundations for managing and conserving biodiversity, spatial planning, or reporting.	Representation of river and inland wetland extent and ecosystem types show that spatial inaccuracies and inland wetlands are particularly under-represented in the National Wetland Maps.	Invest in improved representation and verification of these systems through a combination of citizen science, expert mapping, integration in GIS, and remote sensing methods.	Potentially informing on the spatial and temporal wetland extent, and surface water change of freshwater ecosystems such as coastal and estuarine lakes, using GIS and remotely sensed techniques in chapter 4 and 5.

Thank You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